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REVIEW ARTICLE

Valorizing Durian Fruit Waste: A Path Towards Functional Materials

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Abstract

Durian (*Durio zibethinus*), known as the "King of Fruits," is widely consumed in Southeast Asia. The durian trade has become a high-value industry. Despite its economic value, durian production generates substantial waste (husks, seeds, and pulp), creating environmental and economic challenges. This review explores recent advancements in transforming durian waste into functional materials for industries such as biopolymers, biosorbents, biochar, activated carbon production, and biodiesel catalysis. It highlights the extraction processes, material synthesis techniques, and multifunctional properties of durian-derived materials, emphasizing their environmental and economic benefits. The valorization of durian waste not only addresses waste management concerns but also adds value through the development of sustainable materials. By addressing the challenges of large-scale implementation and exploring innovative valorization strategies, durian fruit waste has the potential to play a pivotal role in advancing sustainable development and promoting a circular bioeconomy. Continued research and development in this field not only enhance waste management practices but also contribute to greener technologies and value-added products, reinforcing the potential of durian waste as a viable raw material in future functional applications.

Keywords: Durian waste, Durian composites, biosorbent, activated carbon, sustainable materials.

Introduction

The tropical Durian fruit (*Durio zibethinus*) belongs to the *Bombacaceae* family. It is a seasonal fruit that is widely grown in tropical areas, mostly in Asia, including the Philippines, Malaysia, Indonesia, and Thailand. Durian pulps, which are famous for being huge and spikey, usually make up 20 to 30 % of the fruit's overall bulk, depending on the type (Pinsorn et al., 2023). The pulp creates many sulfur-containing chemicals, which give it a distinct, unpleasant odor.

This fruit is well-liked in Asian nations because of its high nutritional value and the general acceptance of its processed goods. Being one of the most common fruits in Southeast Asia, durian is a crop with a very high value. Over the past 20 years, the Durian export industry has grown rapidly. According to the most recent data available, globally traded volumes more than tenfold between 2003 and 2022, peaking at 930,000 tonnes in 2021 (Figure 1) (FAO, 2023). This surge in trade has been made possible by significant advancements in cold chain technologies and transit times, as well as income growth and quickly shifting consumer preferences in importing nations, particularly China. Thailand is the world's largest durian exporter, making up an average of 94% of global shipments between 2020 and 2022. Malaysia and Vietnam provide nearly all of the remaining traded quantities, accounting for about 3% of each total. The local market is the primary recipient of Indonesian supplies.

Around 30 to 40 % of the fruit's flesh is eaten (Nguyen, 2024 & Nguyen, et al., 2024). The peel and seed fruits are frequently wasted. The peel makes up the majority of the 85,000 tonnes of durian garbage that are thought to be produced each year (Jumaidin et al., 2023). The fruit's solid outer layer, known as durian peel, has much potential as a natural fiber source. The natural fiber refers to the fibrous material found primarily in the outer husk and inner layer of the peel. Cellulosic fibers are a subset of natural fibers that are specifically rich in cellulose, the primary structural component of plant cell walls. Cellulosic fiber from durian peels has been extracted and used as reinforcement in polymer composites.

The residue of durian peels that is produced in large quantities is primarily made up of cellulose (47.2%), followed by lignin (9.89%), hemicellulose (9.63%), and ash (4.20%) (Adunphatcharaphon et al., 2020). The seeds contain carbohydrates, proteins, and fats, making them suitable for further processing into snacks and flour. These waste products can be repurposed as animal feed, compost, or organic fertilizer due to their high nutrient content, such as potassium, nitrogen, and phosphorus (Chua et al., 2023). They can also be utilized in bioenergy production by converting them into biogas through anaerobic digestion (Shen et al., 2019).

Additionally, the fibrous content of durian husks makes them valuable in industries like pulp and paper manufacturing, and they can even be carbonized to produce activated carbon for water purification (Payus et al., 2021). Durian fiber waste can also enhance food products as a dietary fiber additive. Durian husk flour contains 50% dietary fiber, 34.15% carbohydrate, 6.42% protein, and 0.38% fat (Bunyasawat & Bhoosem, 2018). It can increase the nutritional value of foods due to its high fiber and antioxidant content. Figure 2 shows the schematic diagram of the high value of durian fruit waste applications (Khaksar et al., 2024).

However, improper disposal of durian waste can lead to environmental issues such as odour pollution and overburdened landfills in high-consumption areas. Creatively utilizing durian fiber waste, this may reduce its environmental impact and turn it into valuable resources. In order to create a useful product that has a greater influence on industrial applications, numerous researchers have investigated the elements and importance of durian waste (Chua et al., 2023). This research has focused on converting these wastes into valuable products, supporting the principles of a circular economy and sustainable development.

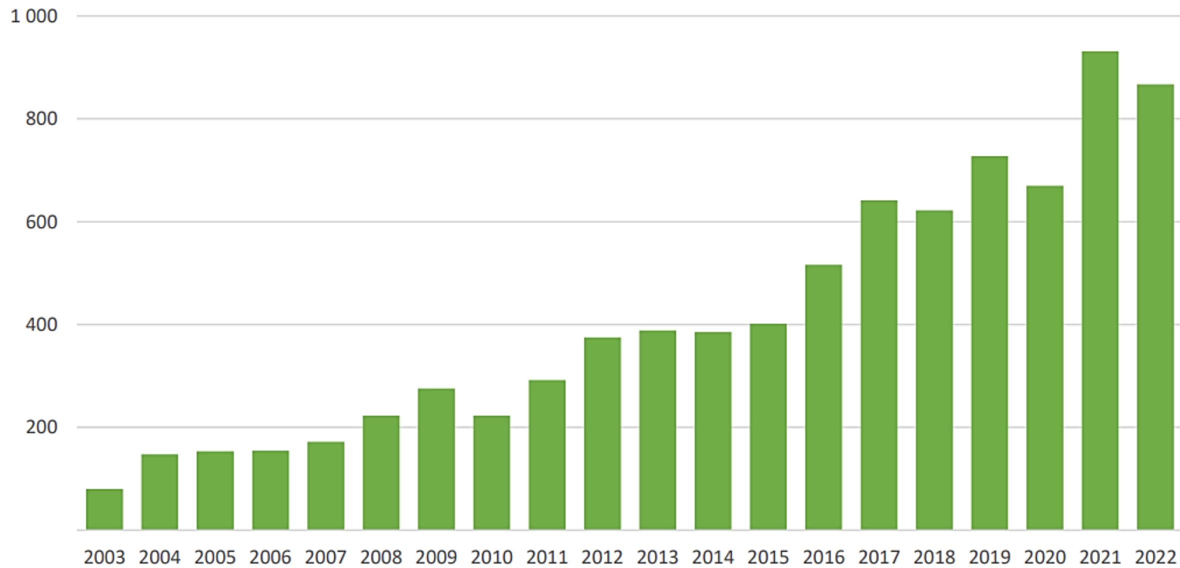

Figure 1. Durian global aggregate export volumes, 2003–2022 (10^3 tonnes) (FAO, 2023)

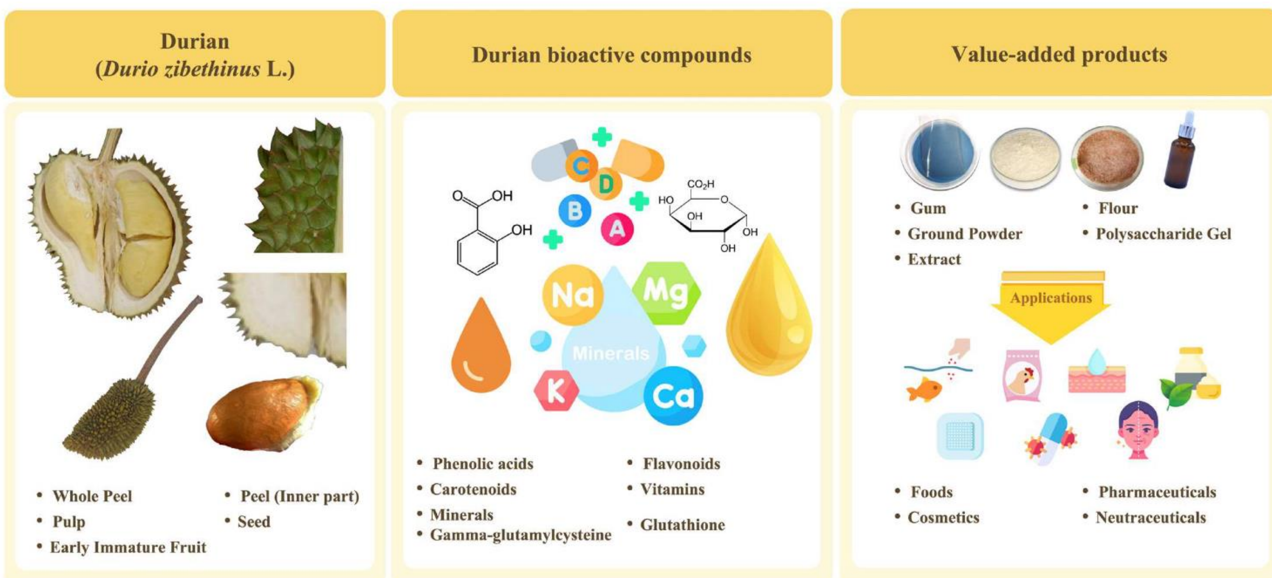

Figure 2. Potential applications of Durian fruit waste (Khaksar et al., 2024)

The Use of Durian Waste

Durian Fiber Composites

Durian fiber, particularly from the husk and rind, is increasingly being explored for its potential in biocomposite materials. These biocomposites are sustainable alternatives to traditional composites, leveraging the natural properties of durian fiber to enhance the performance of biodegradable polymers. Durian fiber is prepared by washing, drying, and chopping the husks into smaller pieces. To eliminate contaminants and enhance fiber-matrix adhesion, the fibers are frequently treated with alkali (such as sodium hydroxide) (Lee et al., 2019). The cellulose-rich fibers are extracted from the treated husks using a mechanical or chemical method. Composites based on durian fiber have been characterized using polyester resin (Sembiring et al., 2018). Density and water content are two physical characteristics of biocomposites that decrease with increasing fiber composition. As the durian fiber content increased, mechanical properties like tensile strength, impact strength, and flexural strength also increased. Further addition of fiber decreased the values of the mechanical properties. The overall results are shown in Figure 3.

A biopolymer known as thermoplastic starch can be produced from natural starch that was obtained from durian fiber by heating it and adding plasticizers. This substance may be repeatedly heated and melted because of its thermoplastic properties. Nonetheless, neat thermoplastic starch has certain drawbacks, such as subpar dimensional stability and mechanical performance (Jayarathna et al., 2022). These drawbacks were frequently attributed to this biopolymer's hydrophilic character, making it extremely susceptible to moisture (Ribba et al., 2017). Since fibres are naturally hydrophobic and have strong interactions with the starch matrix, which prevent water absorption, thermoplastic starch/fiber composites lower moisture content (Prachayawarakorn et al., 2013). According to recent studies, one efficient way to get around the disadvantages of thermoplastic starch is to use natural fiber reinforcement. A study aimed to create and improve thermoplastic cassava starch (TPCS) composites reinforced with durian peel fiber (DPF) (Jumaidin et al., 2023). The DPF was obtained from agro-waste and used in TPCS with different loadings (10, 20, 30, 40, and 50 wt.%) using compression molding. The addition of the DPF improved the thermal properties, as evidenced by a higher onset decomposition temperature and enhanced thermal stability. The composites' biodegradation rate process was also enhanced. Furthermore, the results showed that adding DPF to TPCS composites improved their tensile and flexural qualities. When DPF increased from 0 to 40 wt.%, the TPCS/DPF composites' tensile and flexural strengths increased dramatically from 2.96 to 21.89 MPa and 2.5 to 35.0 MPa, respectively. This study proves that the fiber loading enhanced the thermal and mechanical properties.

The impact of fiber content on the tensile and thermal characteristics of poly(lactic acid) PLA/durian husk fiber (DHF) biocomposites was reported in one study (Lee et al., 2019). The biocomposites' tensile strength and modulus rose as the fiber content rose, although they were less strong than neat PLA. It was then anticipated that a larger fiber content would decrease the biocomposites' elongation at break. Despite a tensile strength of 11 MPa, PLA/DHF biocomposites with 60 phr fiber content are still too brittle for use. PLA biocomposites experienced an early thermal breakdown upon the addition of DHF. Then, as the fiber concentration increased, the thermal stability declined. PLA biocomposites have benefited from the usage of durian skin nanofiber (DSNF), which was developed by freeze-drying (Nordin et al., 2020)These nanofibers increase the composites' tensile strength and hydrophobicity, making them suitable for various uses.

Durian skin fiber has been used in green composite applications by being incorporated into vinyl ester matrix composites (Hastu et al., 2024). However, while DSF enhances elongation at break, it can also decrease modulus and tensile strength. PVA-based biocomposites were developed using treated Durian cellulose fiber (Mahardika et al., 2021). In the PVA matrix, the cellulose fiber from durian peel was varied from 2% to 8%. Biocomposites with a 6% cellulose fiber inclusion have a 54% higher tensile strength (37 MPa) than pure PVA film (24 MPa). On the other hand, it lessens the biocomposite film's elongation at break. Meanwhile, adding cellulose fiber improved the biocomposites' ability to withstand moisture. The uniform distribution of the cellulose fibers and PVA matrix has improved the biocomposites' tensile strength and moisture resistance. These biocomposites use leftover lignocellulosic biomass to lessen their negative effects on the environment.

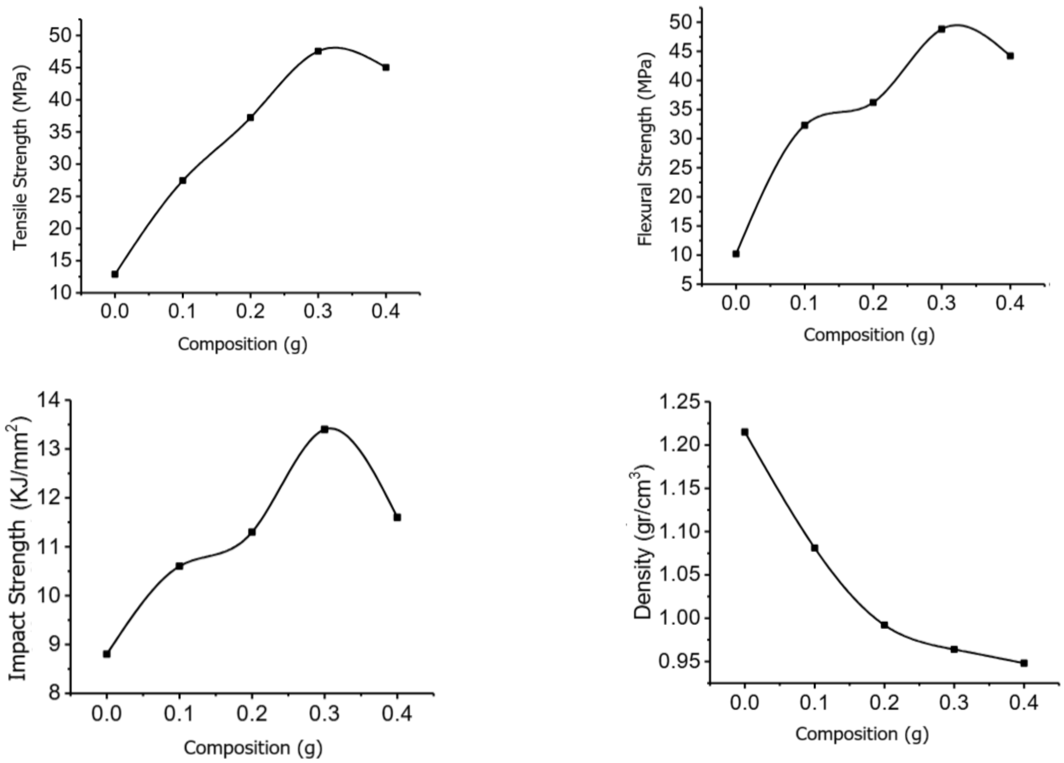

Figure 3. The properties of the polyester/Durian fiber composites (Sembiring et al., 2018)

Durian Fiber Biosorbents

Water pollution from several sources is becoming a serious issue worldwide. For instance, excessive quantities of heavy metals like lead (Pb), chromium (Cr), cadmium (Cd), and mercury (Hg) can result in serious stress and long-term damage (Mitra et al., 2022). Organic dyes, mostly from textile industries, harm aquatic plants' ability to photosynthesize, disturb marine ecosystems, irritate skin and eyes, and cause other problems (Al-Tohamy et al., 2022). Thus, it is now essential to identify ways to eliminate contaminants and lessen their toxicity. Numerous techniques, including chemical precipitation, chemical coagulation, ion exchange, membrane filtration, electrodialysis, and photocatalysis, have been put forth to treat heavy metals (Cai et al., 2024). Adsorption has been regarded as the best option for pollutant removal because of its sensitivity, practicality, ease of use, straightforward design, affordability, efficacy at very low contaminant concentrations, and potential for large-scale use (Oladoye et al., 2024).

Recently, the utilization of biosorbents, especially agricultural waste, has received more attention. Utilizing agricultural waste concurrently addresses two issues: (1) lowering the quantity of agricultural waste and (2) affordably treating wastewater (Desobgo, 2024). The problem can be lessened by turning durian fruit waste into adsorbents. Converting durian waste into adsorbents can efficiently remove current toxins and lower the danger of pollution from trash released into the environment (Osman et al., 2023). Figure 4 shows the potential of durian waste as a biosorbent. Remarkably, around 60–70% of the durian fruit is discarded as waste after consumption. This large volume of organic by-products poses environmental management challenges, especially when not disposed of properly. However, recent studies and innovations in green technology have revealed the potential of durian waste as a valuable resource for environmental applications, particularly as a bioabsorbent material.

Activated carbon, biochar, and biosorbent are the three categories of biosorbents made from durian fruit waste that can be distinguished by their synthesis techniques. The simplest form, biosorbent, can be readily made by washing, chopping, and drying the leftover fruits at temperatures lower than 150 °C. The durian fruit waste biosorbent has a low surface area and no pores, and the cellulose structure is still present at this point, which leads to a moderate adsorption efficiency (Adunphatcharaphon et al., 2020). Durian rind pectin (DRP) and modified durian rind pectin (mDRP) were produced by processing durian rind (Wong et al., 2008).

Two commercial products, citrus pectin (CP) and modified citrus pectin (MCP), were compared with DRP and mDRP as biosorbents for the elimination of hazardous heavy metals (Pb(II), Cd(II), Cu(II), Zn(II), and Ni(II)). Commercial biosorbent MCP demonstrated the best biosorbent capacity, and durian waste product mDRP was also a good sorbent that ought to be taken into account for heavy metal sorption and removal. To improve the surface characteristics, it is suggested that biosorbents be chemically treated with bases or acids to produce new pretreated biosorbents (Yaashikaa et al., 2021).

An investigation into the potential of durian husk to lower total dissolved solids (TDS), electrical conductivity (EC), and water hardness was conducted (Hashim et al., 2022). As a result, the durian husk's ability to remove hardness concentrations has considerably decreased with dosage and settling time. But this was not for the reduction of TDS and EC concentrations, which abruptly increased with a higher dosage. This study used real on-site samples in the field as initial concentrations. The concentration used in this study is too low, at 300 mg/L and below. In contrast, the previous studies used lab-scale synthetic hard water (Man Chee et al., 2018; Payus et al., 2021). Most of them used the highest concentration of hardness, up to 700 mg/L of $CaCO_3$, to determine the removal efficiency for water softening in water treatment using durian husk.

In another study, biochar made from durian fruit waste is made by calcining the raw material at temperatures between 200 °C and 900 °C (Ghani et al., 2024). To remove minerals or other contaminants, biochar is occasionally cleaned using diluted acid or alkaline solutions (Pu et al., 2024). High temperatures during carbonization cause non-carbon components to evaporate, increasing the porosity of the biochar's surface. Biosorbents made from durian fruit waste or biochar impregnated with activators like $ZnCl_2$, NaOH, KOH, and H_3PO_4 can be calcined to create activated carbon (Sakamoto et al., 2019).

Large pores are produced, the interior structure is changed, and functional groups are added. Otherwise, new holes for activated carbons may emerge as a result of physical activation at high temperatures in the presence of steam or CO_2 (Hashim et al., 2022). Carbon from durian fruit waste is combined with one or two other components to create carbon-based composites. Furthermore, the recovery of these biosorbents is facilitated and the removal effectiveness of contaminants is enhanced by the attachment of metals, metal oxides, or ferrites (Satyam & Patra, 2024). Activated carbon (AC) from durian shell waste combined with Manganese ferrite, $MnFe_2O_4$ (MFO) was used by a team of researchers to create a magnetic composite, known as MFOAC, that could adsorb indole (IDO) in water (Nguyen, Tran, et al., 2024). Indole, an odorous N-heterocyclic organic compound (C_8H_7N), finds extensive applications in the perfume and pharmaceutical industries.

Serious organic pollutants like indole have an impact on aquatic life and human health. MFOAC exhibited a microporous structure, as well as a high pore volume and surface area of 0.106 cm^3/g and 518.9 m^2/g, respectively. Figure 5 shows the overall process to synthesizing the biosorbent.

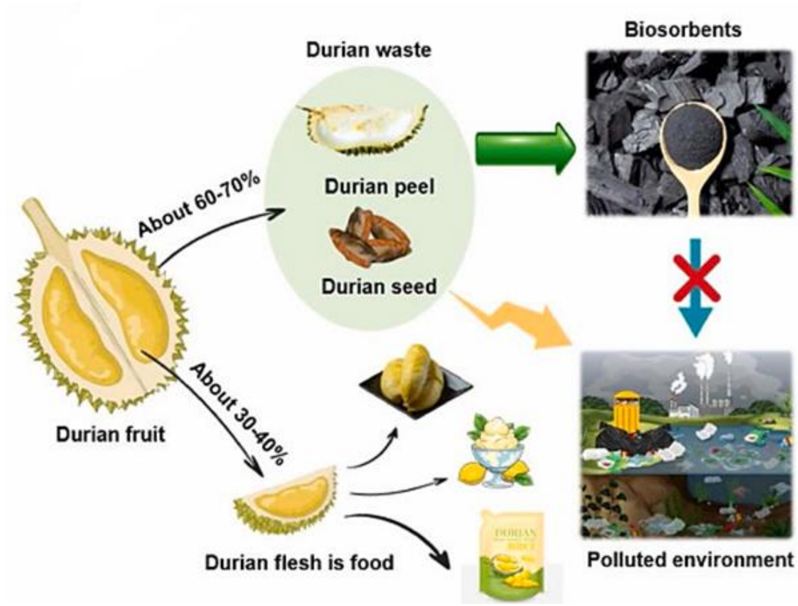

Figure 4. Potential applications of Durian (Nguyen, et al., 2024)

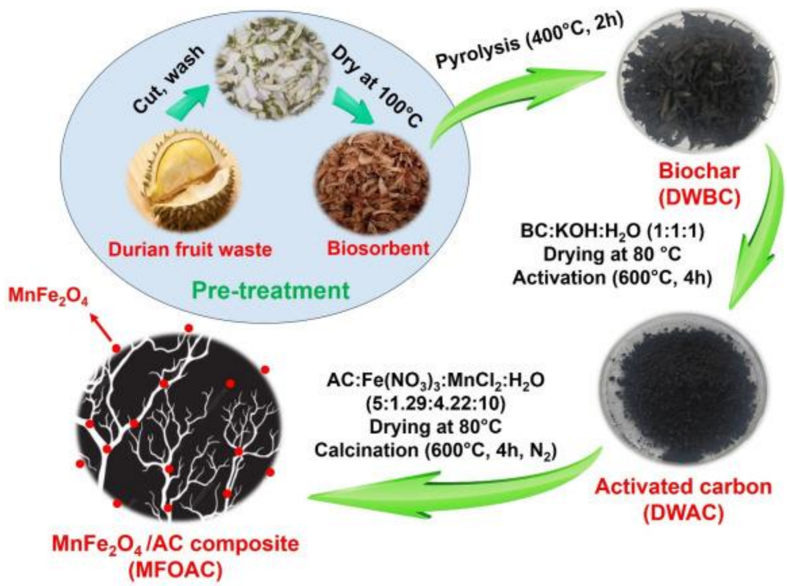

Figure 5. Synthesis diagram of $MnFe_2O_4$/activated carbon derived from durian shell waste (Nguyen, Tran, et al., 2024)

Durian Waste Catalyst for Biodiesel Production

A homogeneous material is now used as a catalyst in the synthesis of biodiesel because of its high activity in catalyzing transesterification processes in a short amount of time. Despite its accessibility and affordability (Zhang et al., 2022), the after-reaction treatment, which includes neutralizing the catalyst and purifying the product, is necessary. The supply of a significant amount of water for post-production operations and wastewater preparation before environmental release presents another issue. As a result, the cost of producing biodiesel as a whole goes up, which may make it less competitive in the fuel market compared to petrodiesel (Naagar et al., 2021). The drawbacks of homogeneous catalysts have been addressed by the development of heterogeneous materials. Heterogeneous catalysts provide several benefits, including non-corrosiveness, environmental friendliness, resistance to moisture and FFAs, and simplicity of recycling and reuse (Qamar et al., 2023). Nowadays, it has been demonstrated that heterogeneous catalysts made from agricultural waste biomass, including banana peels, cocoa pod husks, walnut shells, passion fruit peels, coconut husks, and palm bunch ash, have catalytic activity comparable to homogeneous material (Tarigan et al., 2022).

The transesterification of palm oil to biodiesel at room temperature has been successfully catalyzed by calcined biowaste durian peel (BDP), which has an 86% potassium element as its primary component (Sitepu et al., 2024). The highest biodiesel conversion was 97.4 ± 0.3%. The calcined BDP, regrettably, was unable to maintain its catalytic activity during the reusability study. Both the catalyst weight and the potassium ion concentration dropped after the first cycle, which resulted in a lower biodiesel conversion in the second cycle. In turn, when combined with a homogenizer, the calcined BDP may quickly react and make biodiesel at room temperature (Sitepu et al., 2024). A study prepared Chicken eggshell and Durian peel biosorbent by the carbonization process to treat the used cooking oil (Kristanto et al., 2021).

The results showed that the acid number of cooking oil met the parameters approved by the Indonesian government to be pursued with the transesterification process to produce the biodiesel. Another study examined the viability of using durian rinds to remove nitrates and chemical oxygen demand (COD), two contaminants found in wastewater, through a technique known as adsorption (Musthapa et al., 2022). Before being used, the fruit peel study undergoes a dehydration and carbonization process. An adsorption capacity of 690 mg/g was determined to have a maximum COD elimination percentage of 68.2%. Table 1 shows studies involving biodiesel production by using Durian waste catalysts.

Table 1. Biodiesel production using durian-derived biochar as a catalyst

Durian-derived biochar	**Oil feedstock**	**Type of production**	**Parameter**	**Oil:MeOH ratio**	**Catalyst loading (wt.%)**	**Biodiesel yield**	**Reference**
Peel	Palm oil	Transesterification	10 min, 6000 rpm.	1:15	5	97.4 ± 0.3%	(Sitepu et al., 2024)
Peel	Rubber seed oil	Transesterification	65 °C, 1 hr	1:8	1–15	81.21–96.50	(Saygin & Gielen, 2021)
Skin	Palm oil	Methanolysis	65 °C,	1:6	5	96.21	(Yanti et al., 2020)
Shell	Refined bleached and deodorized palm oil	Transesterification	65 °C, 500 rpm	1:12	2–4	90.77–92.85	(Munawar et al., 2020)

Conclusion

Durian waste holds significant promise as a resource for functional applications in diverse industries. These waste materials are rich in bioactive compounds, cellulose, and starch, making them suitable for applications such as biofuel production, biodegradable packaging, and wastewater treatment. The conversion of durian waste into biochar can contribute to the reduction of environmental pollution and the promotion of a circular economy. Future research should focus on optimizing extraction methods, improving scalability, and addressing possible market opportunities, conducting a cost-benefit analysis, or highlighting industrial interest to demonstrate practical feasibility. Overall, durian waste valorization presents an eco-friendly approach to waste management while contributing to environmental sustainability and economic growth.

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References

Adunphatcharaphon, S., Petchkongkaew, A., Greco, D., D'Ascanio, V., Visessanguan, W., & Avantaggiato, G. (2020). The effectiveness of Durian peel as a multi-mycotoxin adsorbent. *Toxins*, *12*. https://doi.org/10.3390/toxins12020108

Al-Tohamy, R., Ali, S. S., Li, F., Okasha, K. M., Mahmoud, Y. A.-G., Elsamahy, T., Jiao, H., Fu, Y., & Sun, J. (2022). A critical review on the treatment of dye-containing wastewater: Ecotoxicological and health concerns of textile dyes and possible remediation approaches for environmental safety. *Ecotoxicology and Environmental Safety*, *231*, 113160. https://doi.org/https://doi.org/10.1016/j.ecoenv.2021.113160

Bunyasawat, J., & Bhoosem, C. (2018). Effect of using Durian rind powder substitution with wheat flour on Brownies cake quality. *RMUTP Research Journal Sciences and Technology*, *12*(1 SE-บทความวิจัย (Research Articles)), 113–124. https://doi.org/10.14456/jrmutp.2018.10

Cai, Y., Fang, M., Tan, X., Hu, B., & Wang, X. (2024). Highly efficient selective elimination of heavy metals from solutions by different strategies. *Separation and Purification Technology*, *350*, 127975. https://doi.org/https://doi.org/10.1016/j.seppur.2024.127975

Chua, J. Y., Pen, K. M., Poi, J. V., Ooi, K. M., & Yee, K. F. (2023). Upcycling of biomass waste from durian industry for green and sustainable applications: An analysis review in the Malaysia context. *Energy Nexus*, *10*, 100203. https://doi.org/https://doi.org/10.1016/j.nexus.2023.100203

Desobgo, S. (2024). *Utilization of agricultural waste for water and wastewater treatment processes* (pp. 295–320). https://doi.org/10.1007/978-3-031-61133-9_13

FAO. (2023). Durian Global Trade Overview 2023. In *Food and Agriculture Organization of the United Nations*.

Ghani, M. A., Hashim, N., Emran, M. F., & Besar, M. B. (2024). Optimizing application of Melaleuca Cajuputi biochar on removing H2S odour from poultry manure. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, *47*(1), 199–205.

Hashim, N., Abd Ghani, M., Emran, M. F., & Besar, M. B. (2022). Synthesizing the biochar from Gelam tree leaves by pyrolysis method. *International Journal of Synergy in Engineering and Technology*, *3*(2), 143–149.

Hastu, M. O. P., Silitonga, J. B., Asrofi, M., Laksana, D. D., Pradiza, R., & Setyawan, H. (2024). Mecanical properties of biocomposites with unsaturated vinyl ester natrix reinforced with Durian skin fiber as a green composite application. *Proceeding of International Conference on Artificial Intelligence, Navigation, Engineering, and Aviation Technology (ICANEAT)*. https://doi.org/10.61306/icaneat.v1i1.220

Jayarathna, S., Andersson, M., & Andersson, R. (2022). Recent advances in starch-based blends and composites for bioplastics applications. In *Polymers* (Vol. 14, Issue 21). https://doi.org/10.3390/polym14214557

Jumaidin, R., Whang, L. Y., Ilyas, R. A., Hazrati, K. Z., Hafila, K. Z., Jamal, T., & Alia, R. A. (2023). Effect of durian peel fiber on thermal, mechanical, and biodegradation characteristics of thermoplastic cassava starch composites. *International Journal of Biological Macromolecules*, *250*, 126295. https://doi.org/https://doi.org/10.1016/j.ijbiomac.2023.126295

Khaksar, G., Kasemcholathan, S., & Sirikantaramas, S. (2024). Durian (Durio zibethinus L.): Nutritional Composition, Pharmacological Implications, Value-Added Products, and Omics-Based Investigations. In *Horticulturae* (Vol. 10, Issue 4). https://doi.org/10.3390/horticulturae10040342

Kristanto, D., Pudjihastuti, I., & Amalia, R. (2021). The effectiveness of biosorbent from Chicken's egg shell and Durian peel towards the quality of biodiesel product from waste cooking oil. *Journal of Vocational Studies on Applied Research*, *3*(2), 42–46. https://doi.org/10.14710/jvsar.v3i2.12620

Lee, M., Koay, S. C., Chan, M. Y., Choo, H. L., Pang, M., Chou, P., & Tshai, K. Y. (2019). Properties of Poly(lactic acid)/Durian husk fiber biocomposites: Effects of fiber content and processing aid. *Journal of Thermoplastic Composite Materials*, *33*. https://doi.org/10.1177/0892705719831734

Mahardika, M., Asrofi, M., Amelia, D., Syafri, E., Rangappa, S., & Siengchin, S. (2021). Tensile strength and moisture resistance properties of biocomposite films based on polyvinyl alcohol (PVA) with cellulose as reinforcement from Durian peel fibers. *E3S Web of Conferences*. https://doi.org/10.1051/e3sconf/202130202001

Man Chee, L., Koay, S. C., Chan, M. Y., Pang, M. M., Chou, P. M., & Tsai, K. Y. (2018). Preparation and characterization of durian husk fiber filled polylactic acid biocomposites. *MATEC Web of Conferences*, *152*, 2007.

Mitra, S., Chakraborty, A. J., Tareq, A. M., Emran, T. Bin, Nainu, F., Khusro, A., Idris, A. M., Khandaker, M. U., Osman, H., Alhumaydhi, F. A., & Simal-Gandara, J. (2022). Impact of heavy metals on the environment and human health: Novel therapeutic insights to counter the toxicity. *Journal of King Saud University - Science*, *34*(3), 101865. https://doi.org/https://doi.org/10.1016/j.jksus.2022.101865

Munawar, A., Taslim, Manurung, R., & Iriany. (2020). Biodiesel synthesis from refined bleached and deodorized palm oil (RBDPO) by transesterification using durian shell based carbon modified with KOH as heterogeneous catalyst. *IOP Conference Series: Materials Science and Engineering*, *725*(1), 12063. https://doi.org/10.1088/1757-899X/725/1/012063

Musthapa, S. M., Shams, S., & D.M, R. P. (2022). Removal of pollutants from wastewater using activated carbon from durian peel. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1135). https://doi.org/10.1088/1755-1315/1135/1/012001

Naagar, M., Chalia, S., Thakur, P., Sridhara, S. N., Thakur, A., & Sharma, P. B. (2021). Nanoferrites heterogeneous catalysts for biodiesel production from soybean and canola oil: a review. *Environmental Chemistry Letters*, *19*(5), 3727–3746.

Nguyen, N. T. H., Nguyen, T. T. T., Nguyen, D. T. C., & Tran, T. Van. (2024). A comprehensive review on the production of durian fruit waste-derived bioadsorbents for water treatment. *Chemosphere*, *363*, 142801. https://doi.org/https://doi.org/10.1016/j.chemosphere.2024.142801

Nguyen, N. T. H., Tran, G. T., Nguyen, T. T. T., Nguyen, D. T. C., & Tran, T. Van. (2024). Synthesis of MnFe2O4/activated carbon derived from durian shell waste for removal of indole in water: Optimization, modelling, and mechanism. *Environmental Research*, *254*, 118883.

https://doi.org/https://doi.org/10.1016/j.envres.2024.118883

Nordin, M., Anuar, H., Buys, Y., Ali, F., Thomas, S., & Nasir, N. A. M. (2020). Effect of freeze-dried durian skin nanofiber on the physical properties of poly(lactic acid) biocomposites. *Polymer Composites*. https://doi.org/10.1002/pc.25869

Oladoye, P. O., Kadhom, M., Khan, I., Hama Aziz, K. H., & Alli, Y. A. (2024). Advancements in adsorption and photodegradation technologies for Rhodamine B dye wastewater treatment: fundamentals, applications, and future directions. *Green Chemical Engineering*, *5*(4), 440–460. https://doi.org/https://doi.org/10.1016/j.gce.2023.12.004

Osman, A. I., El-Monaem, E. M. A., Elgarahy, A. M., Aniagor, C. O., Hosny, M., Farghali, M., Rashad, E., Ejimofor, M. I., López-Maldonado, E. A., Ihara, I., Yap, P.-S., Rooney, D. W., & Eltaweil, A. S. (2023). Methods to prepare biosorbents and magnetic sorbents for water treatment: a review. *Environmental Chemistry Letters*, *21*(4), 2337–2398. https://doi.org/10.1007/s10311-023-01603-4

Payus, C. M., Refdin, M. A., Zahari, N. Z., Rimba, A. B., Geetha, M., Saroj, C., Gasparatos, A., Fukushi, K., & Alvin Oliver, P. (2021). Durian husk wastes as low-cost adsorbent for physical pollutants removal: groundwater supply. *Materials Today: Proceedings*, *42*, 80–87. https://doi.org/https://doi.org/10.1016/j.matpr.2020.10.006

Pinsorn, P., Sanachai, K., Rungrotmongkol, T., Hoefgen, R., Watanabe, M., Brueckner, F., Nakabayashi, R., Mori, T., Oikawa, A., Sasaki, R., Sucharitakul, J., Saito, K., & Sirikantaramas, S. (2023). Sulfur metabolism in durian pulps: Factors contributing to the production of volatile sulfur compounds during fruit ripening. *Postharvest Biology and Technology*, *206*, 112533. https://doi.org/10.1016/j.postharvbio.2023.112533

Prachayawarakorn, J., Chaiwatyothin, S., Mueangta, S., & Hanchana, A. (2013). Effect of jute and kapok fibers on properties of thermoplastic cassava starch composites. *Materials & Design*, *47*, 309–315. https://doi.org/https://doi.org/10.1016/j.matdes.2012.12.012

Pu, Y., Jin, N., Xiong, Y., Chen, J., Liu, R., Tang, J., Wang, Q., & Abomohra, A. (2024). Performance of bioenergy production from Durian shell wastes coupled with dye wastewater treatment. *Water*. https://doi.org/10.3390/w16182688

Qamar, O. A., Jamil, F., Hussain, M., Bae, S., Inayat, A., Shah, N. S., Waris, A., Akhter, P., Kwon, E. E., & Park, Y.-K. (2023). Advances in synthesis of TiO2 nanoparticles and their application to biodiesel production: A review. *Chemical Engineering Journal*, *460*, 141734.

Ribba, L., Garcia, N. L., D'Accorso, N., & Goyanes, S. (2017). *Chapter 3 - Disadvantages of starch-based materials, feasible alternatives in order to overcome these limitations* (M. A. Villar, S. E. Barbosa, M. A. García, L. A. Castillo, & O. V. B. T.-S.-B. M. in F. P. López (eds.); pp. 37–76). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-809439-6.00003-0

Sakamoto, T., Zaini, M., Amano, Y., & Machida, M. (2019). Preparation and characterization of activated carbons produced from oil palm empty fruit bunches. *Carbon*. https://doi.org/10.7209/TANSO.2019.9

Satyam, S., & Patra, S. (2024). Innovations and challenges in adsorption-based wastewater remediation: A comprehensive review. *Heliyon*, *10*(9), e29573. https://doi.org/https://doi.org/10.1016/j.heliyon.2024.e29573

Saygin, D., & Gielen, D. (2021). Zero-emission pathway for the global chemical and petrochemical sector. In *Energies* (Vol. 14, Issue 13, p. 3772). https://doi.org/10.3390/en14133772

Sembiring, T., Kristiarawati, Sebayang, K., & Sinuhaji, P. (2018). Characterization of biocomposite materials based on the Durian fiber (Durio Zibethinus Murr) reinforced using polyester resin. *Journal of Physics:*

Conference Series, *1116*, 32031. https://doi.org/10.1088/1742-6596/1116/3/032031

Shen, J., Zhao, C., Liu, Y., Zhang, R., Liu, G., & Chen, C. (2019). Biogas production from anaerobic co-digestion of durian shell with chicken, dairy, and pig manures. *Energy Conversion and Management*, *198*, 110535. https://doi.org/https://doi.org/10.1016/j.enconman.2018.06.099

Sitepu, E. K., Sinaga, R. P. A., Sitepu, B. E. N., Santoso, A., Susilo, B., Ginting, B., Perangin-angin, S., & Tarigan, J. B. (2024). Calcined biowaste Durian peel as a heterogeneous catalyst for room-temperature biodiesel production using a homogenizer device. *ACS Omega*, *9*(13), 15232–15238. https://doi.org/10.1021/acsomega.3c09642

Tarigan, J. B., Singh, K., Sinuraya, J. S., Supeno, M., Sembiring, H., Tarigan, K., Rambe, S. M., Karo-Karo, J. A., & Sitepu, E. K. (2022). Waste passion fruit peel as a heterogeneous catalyst for room-temperature biodiesel production. *ACS Omega*, *7*(9), 7885–7892.

Wong, W. W., Abbas, F. M. A., Liong, M. T., & Azhar, M. E. (2008). Modification of durian rind pectin for improved biosorbent ability. *International Food Research Journal*, *15*(3), 363–365.

Yaashikaa, P. R., Kumar, P. S., Saravanan, A., & Vo, D.-V. N. (2021). Advances in biosorbents for removal of environmental pollutants: A review on pretreatment, removal mechanism and future outlook. *Journal of Hazardous Materials*, *420*, 126596. https://doi.org/https://doi.org/10.1016/j.jhazmat.2021.126596

Yanti, D., Husin, H., Yani, F. T., Maulana, A., Adisalamun, A., & Husaini, H. (2020). Transesterification of Pangium Edule Reinw oil to biodiesel using durian rind ash as heterogeneous catalysts. *IOP Conference Series: Materials Science and Engineering*, *845*(1), 12031. https://doi.org/10.1088/1757-899X/845/1/012031

Zhang, Y., Duan, L., & Esmaeili, H. (2022). A review on biodiesel production using various heterogeneous nanocatalysts: Operation mechanisms and performances. *Biomass and Bioenergy*, *158*, 106356.

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